Ministry of Municipal Affairs and Housing | Ministry of Energy

Ontario

SYSTEMS REPORT

SOLAR APARTMENT BUILDING

AYLMER, ONTARIO

A Community Energy Management Program Report

Energy Ontario

SYSTEMS REPORT

SOLAR APARTMENT BUILDING

AYLMER, ONTARIO

Undertaken jointly by the Ontario Ministries of Municipal Affairs & Housing and Energy under the Community Energy Management Program (C.E.M.P.)

Prepared for
Ontario Ministry of Municipal Affairs & Housing
Technical Services Division
Research and Development Section

By

M. M. Dillon Limited

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1. BACKGROUND

Mr. G. E. Humphries of M. M. Dillon Limited was instructed by Mr. Andrew Zdanowicz, Manager of Research and Development Section, Ontario Ministry of Municipal Affairs and Housing, to prepare a report summarizing the operations of the Solar Heating System at the Senior Citizens Apartments in Aylmer, Ontario.

2. OBJECT

The purpose of this report is to provide a summarized review of the system since completion of construction to the present, and report on changes made to improve operation.

3. METHOD

A review was made of all available information including original design and construction data, operational records, reports by Dillon and records of changes in the system and method of operation.

4. ORIGINAL SYSTEM

4.1 General

Appendix "A" is a Schematic Drawing showing the system as it was on completion of construction and after some modifications had been made by the original designers.

The system was generally as described below.

4.2 Building

The building is located at 58 Myrtle Street, Aylmer, Ontario. It is a two-storey brick building with 30 apartment units.

4.3 Collector System

There are 112 solar collector panels with a total area of 218.6 m^2 mounted on the roof at a 60° slope to the horizontal in two rows, one above the other.

Panels are 2.13m high x 0.92m wide with an area of 1.95m^2 each.

The building is oriented so that the panels face a number of degrees to the west of due south.

Panels are connected in series - parallel with a reversed return system. There are no balancing valves or shut-off valves to individual panels.

Water is pumped from the bottom of the storage tank by Pump Nos. 3 and 4, each of which has a capacity of 5.8 L/s. One pump only runs at a time but they alternate on each start.

A controller in a solar panel starts both pumps when the temperature difference between the collector and the storage tank water is 9.4°C. After a set period, one pump will stop. The second pump will run until the difference is less than 1°C. An automatic drain-down system operates when outdoor temperature is below 5°C if there is no flow in circulating system.

4.4 Storage

Heat storage is in a below ground concrete tank holding 886 m^3 water.

Tank is insulated on the inside with 152 mm of field-applied urethane foam. The original design included a floor drain in the centre of the tank bottom below the insulation in a flat

portion of the bottom filled with 75 mm of granular material intended as an under-drain.

The whole inside surface of the foam insulation was sprayed with 0.53 mm of a butyl elastomer waterproofing, trade name "Elastron X". This in turn was covered by a sprayed-on coating, of urethane waterproofing, 1.14 mm thick, trade name "Flexcell S".

Concrete roof of tank is supported on steel decking on open web steel joists. Roof had asphalt roofing and was covered with 50 mm concrete lockstones. Bottom of joists carried the tank interior ceiling of 152 mm thick sprayed urethane foam coated with butyl elastomer waterproofing, "Elastron X", 0.53 mm thick.

4.5 Heating System

Heating of the building was to be supplied by circulating hot water from the storage tank. A 30 kW electric boiler was installed as a stand-by.

There are two pumps serving the heating system - No. 1 having a capacity of 3.5 L/s and No. 2, 7.6 L/s.

When heating with storage tank water, Pump No. 1 operates as long as tank water is above 43°C. When water drops below 43°C, Pump No. 1 stops and Pump No. 2 operates. This pump will operate until shut off manually or until tank temperature rises above 43°C when Pump No. 1 will take over.

Temperature of water to the system is controlled at 32-43°C by a three-way mixing valve which blends return water and tank water under control of two aquastats.

When operating on stand-by boiler water, Pump No. 2 is in operation and the three-way valve goes to full recirculation, the system then becomes a closed circulation system. Water temperature is controlled by an aquastat on the electric boiler through a two-step relay system. In order to supplement solar heat with electric heat at off-peak electric periods, a timer-relay system can be set to change the mode from electric to solar and to revert at selected times each day. A manual switch is also installed which allows instant change-over.

Apartment units are heated by fan coil units, the fans being under control of individual thermostats and three-speed manual fan switches.

Air is exhausted from the kitchens and bathrooms passing to the outside through a heat recovery wheel. A supply fan delivers make-up air to the corridors drawing heat from the heat recovery wheel and from a hot water coil in the fan discharge. Coil is controlled to maintain supply air at 21°C. Fan is shut down at night and started in the morning by a time clock control. In summer, the heat wheel is switched off for the season.

4.6 Domestic Hot Water

The domestic hot water system has a preheater tank to which water from the storage tank is circulated through a coil in the tank by Pump P6 which has a capacity of 0.6 L/s. An aquastat on the preheater tank shuts down the pump when water in the tank reaches 49°C and restores it when the temperature falls to 46°C. Preheater tank has a storage capacity of 900L. An electrically heated tank is installed in series with the preheater to supply additional heat when required. A circulating pump P5, with a capacity of 0.6 L/s, circulates domestic hot water through the system.

4.7 Monitoring System

During the construction period, an extensive monitoring system was installed by National Research Council. Integrating heat meters are installed in the piping system to measure the amounts of solar heat collected, solar energy delivered to space and solar energy used for domestic hot water preheating. A solar pyrometer is installed on the roof to provide a signal for measuring solar radiation. Weather conditions including wind speed and direction, humidity and temperature are all measured.

Air flow in the mechanical ventilation system is measured, also the pressure drop across the heat recovery wheel. All electric power used on motors, for pumps, ventilation fans and auxiliary boiler is measured by individual kWh meters. Total electrical power is also monitored.

In addition to the above, the storage tank has a number of temperature sensors.

Information from all these sources is fed to a mini-computer with 28K memory, dual floppy disc unit and a keyboard printer. For each of the 120 channels, the system calculates a running integral based on 30-second scans. On-line Fortran routine performs running integrations of key performance measurements, and feeds results to a visual display panel, located in the building lobby.

Discs and printouts from the computer are regularly dispatched to Ottawa for analysis. The system incorporates an automatic power-failure restart system.

To date, very little useable information has been made available from the operation of this monitoring system.

5. EARLY HISTORY OF OPERATION

The system was put into operation early in 1979. Solar heat collection started in June 1979.

Any heating done in the winter 78-79 was by the electric boiler. Changes had to be made to the heating system by provision of an air cushion tank, a pressure regulation device and addition of valves to enable the system to function properly when using the electric boiler.

By the end of September 1979, the solar storage tank was full of water with an average temperature of 66°C.

In July 1979, it became apparent that water was leaking from the storage tank. This gradually increased and by October had reached a rate of 6,800L per day.

At this time, Dillon was hired to give advice on future action.

Late in 1979 and in January 1980, meetings were held to discuss the problem. These were attended by personnel from Ministry of Municipal Affairs and Housing, Design Architects and Engineers, Contractor, Ministry of Energy and Dillon. A decision was made to drain the tank to the Town sanitary sewer system.

Tests by Ontario Ministry of Environment showed significant contamination of the tank water by a pathogen, pseudomonas aeruginosa. They required that the water be chlorinated before being pumped to the sewage system. This was done and the tank was emptied by 8 February 1980.

There was, therefore, no space heating from the solar storage tank used up to this time as the leak prevented usage in the

Fall of 1979. The domestic hot water preheater system functioned for only short periods for reasons which were unknown at that time. The total amount of collected heat which was lost due to tank leakage totalled (66 - 10°C) x 886 000 kg x 0.004186 equal to 207 700 MJ total energy. The usable heat lost, 66-32°C, was 126 100 MJ.

6. INVESTIGATION

6.1 Storage Tank

A thorough inspection of the storage tank was carried out by Dillon and by representatives of Ontario Housing Corporation, Ministry of Municipal Affairs and Housing and National Research Council. Entrance to the tank was made by a ladder provided by the General Contractor. Temporary electric lighting had been installed. As a result of this inspection the following findings were made.

.1 A number of circumferential cracks had developed in the coating and insulation at the point where the flat, gravel-covered bottom of the tank joined the sloping concrete section. Water had penetrated the foam and leaked into the gravel layer and so through the floor drain to the sump. By cutting into the foam at a few of these leaks it was apparent that the original leaks had increased in size due to erosion of the softened foam which accounted for the increased leakage over a period of time.

.2 The urethane foam varied greatly in thickness from 125 to 305 mm. The surface was very uneven.

.3 The urethane coating also varied in thickness. Some areas in the bottom of the tank had thicknesses up to 9.5 mm. In the bottom of the tank a second layer had

been applied which did not adhere to the first layer and could be easily peeled off. This was no doubt due to applying the second layer after curing of the first was complete. The coating was generally in good condition.

.4 There was a damaged section of foam in the upper wall of the tank. This appeared to have been caused by a ladder during construction.

.5 The steel joists supporting the tank roof were badly rusted and water had condensed on the underside of the roof slab. The relative humidity in this space registered 100 per cent. It was apparent that there was a vapour leak between the tank proper and the roof space and that the ventilation provided for this space was not effective.

.6 The two hatch frames and covers from the ceiling space were crudely made and very difficult to open. There was no direct access from outside to these openings. It was necessary to enter the ceiling space and then crawl over to the hatches. As this space was only 762 mm high, this was a difficult process.

6.2 Mechanical System

An examination was made of the mechanical system as a whole. The operation was tested and the operator pointed out several shortcomings. The following points were noted:

.1 The Mechanical Room was very congested, making operation and maintenance difficult.

.2 The three-way control valve on the heating system did not operate.

.3 Controls were located in various places and they were not marked.

.4 There was insufficient written information on the Drawings to enable the operator to properly understand the system.

7. REPAIRS AND MODIFICATIONS

7.1 Preliminary Work

The Ministry of Municipal Affairs and Housing, together with the Ministry of Energy, were hopeful of getting the system back in operation in order to collect solar heat during the Summer of 1981. It was felt that a solution providing some more years of operation would allow a proper evaluation of the system in regard to the achievement of the original objective.

The main emphasis was on the repair of the storage tank. A large number of methods were studied during the preliminary phase. Several of these were considered worthy of further investigation and these were dealt with in more detail and reported on by Dillon. Laboratory tests were carried out on a variety of proposed materials by NRC and Dillon. The proposals studied in detail were as follows:

.1 Installation of new steel tank inside existing tank. This would involve removing tank roof, and removing inside piping, construction of steel tank on site from prefabricated components, lowering tank inside existing, filling space around tank, coating steel with epoxy, reinstalling piping.

.2 Repair of existing insulation and coating after plugging drain. This would involve removing foam and gravel on

flat portion of tank botton, plugging centre drain, installing 150 mm of new foam on botton, patching and sealing any cracks, spraying new waterproofing on entire interior of floors and walls, pouring reinforced concrete over bottom of tank to provide weight and protect coating.

.3 Lining of tank with sprayed concrete after waterproofing. This would involve plugging of drain without removing foam on floor, installing anchors through foam into walls and floor, spraying new waterproofing over whole interior, spraying of concrete, "Gunite", 75 mm, over wire mesh attached to anchors over floor and walls, placing 1m of gravel over floor to prevent uplift.

.4 Repair and replacement of foam insulation, installation of EPDM membrane. This involved removal of all foam on the walls, covering bottom of tank with smooth concrete, installation of new foam in block form to walls, covering with galvanized steel, installation of 1.6 mm EPDM membrane fastened to walls with adhesive and loose over concrete on bottom of tank.

.5 Installation of FRP liner. This would involve removal and replacement of foam on walls, installation of 5 mm thick fibre reinforced plastic, laid up by hand.

All methods except .2 and .4 were eliminated because of high prices or serious doubts about their feasibility. The final decision was to use .2 with some modifications.

A decision was also made to improve access to the tank and to modify the ventilation system.

7.2 Execution of Work

On instructions from the Ministry of Municipal Affairs and Housing, Drawings and Specifications were prepared and Tenders called. A decision was made on the insulation and waterproofing to be used based on tests and information available. The new insulation on the floor was to be based on the use of CIL 251 spray system. The waterproofing was to be Zebron 386, as supplied by Zebra Coatings, West Vancouver, B.C. and spray-applied 1.27 mm thick. Approved applicator was Chem-Thane Engineering, Concord, Ontario.

A contract was awarded to John Hayman and Sons of London for the work in December 1980. This included the following:

a) Installation of new central access hatch to tank.

b) Modification to existing hatch on southwest perimeter of tank.

c) Removal of foam and gravel on flat portion of floor of tank.

d) Plugging of existing drain in bottom of tank.

e) Installation of ventilation system for space above storage tank.

f) Cleaning and preparation of existing coating.

g) Installation of new foam, 152 mm thick on flat portion of tank bottom.

h) New waterproof coating on new foam and on existing coating on sloping part of bottom up to vertical walls.

i) Placing concrete over insulation and waterproofing on bottom of tank.

j) Installation of new diffuser on return pipe from solar panels and carrying pipe below water level.

k) Installation of new intake for heating system through tank wall below water level.

l) Refilling tank with softened, treated water.

This work was completed and the tank filled in April 1981.

The solar system worked satisfactorily in collecting heat. Tests, however, showed a number of deficiencies in the heating system and the DHW preheating system.

It had been intended that the original design should incorporate an automatic switch-over system so that advantage could be taken of off-peak electricity rates when auxiliary heat was needed to supplement the stored solar heat. This proved impossible as the heating circuit operated as a closed system when on the electric boiler and an open system when using tank water. The change-over involved manual manipulation of a number of valves, as well as operation of a change-over switch on the controls.

The domestic hot water preheater system was not operating properly. Tests showed that tank water was not being circulated through the preheater. NRC records indicated that the system had operated at times during 1979.

The three-way valve was not controlling the water temperature to the heating system.

It was determined that these problems could be corrected by a number of modifications to the system and these were carried out.

In the Summer of 1981, further modifications were made as follows:

.1 Installation of a primary loop with separate pump and control valves. All this was installed in the existing entrance pit on the southwest side of the tank. A new hatch cover was needed to make this pit weathertight.

.2 Correction of deficiencies in the original wiring and controls.

This work was completed in August 1981 and was put in operation after calibration. Subsequent to this it was reported by the consultants of NRC that the computer part of the monitoring system was performing erratically due to excessive ambient temperature. A system to maintain suitable operating temperatures in the room housing the computer equipment has been installed and is working satisfactorily.

The present system is shown in Appendix "B".

8. OPERATION SUBSEQUENT TO REPAIRS AND MODIFICATIONS

8.1 Operating Performance

In April 1981 collection of solar heat was commenced. On the 27 April 1981, the average temperature in the tank was 10°C. The monitoring system was not operating for some months so operational reports were not made for July and August.

Some of the tank temperatures reported were:

1 June 1981	31.0°C
1 September 1981	61.5°C
1 October 1981	62.0°C

Up to that time no heat had been used, therefore, the heat added to the tank would be 193 500 MJ. In April 1981, when the tank was repaired and put back into operation, it was filled with water at 10°C. The total heat required to bring this to a useable temperature of 32°C would be 81 900 MJ. The amount of heat collected from 1 October 1981 to 20 January 1982 had to be estimated as the monitoring system was inoperable during that period. Based on climatic conditions and previous experience, it was estimated at 70 000 MJ. Allowing 15% loss, this resulted in an addition to storage of 60 000 MJ.

During the week of 17 to 23 January 1982, it was discovered that the tank was losing water. An investigation showed that four of the collectors, all in the lower row, were leaking badly. On 17 January, when it is believed the leak started, the temperature of storage was 38°C. Collection ceased shortly after this, and did not commence again until 2 April 1982 after installation of shut-off valves on the leaking collectors allowed the pumps to be restarted.

About 36 000 litres of water was added to the tank. This represented a loss of heat of 4 200 MJ. Between the time that the collector system was restarted, and the end of April 1982, the temperature of the storage increased from 26.0°C to 37.2°C, representing an increase of heat storage of 38 000 MJ. The total amount of heat added to storage for the year is 192 500 + 60 000 + 4 200 + 38 000 = 296 000 MJ. Allowing 15% loss, this represents a total collected for the year of 348 000 MJ.

The amount of heat used for space and domestic hot water heating cannot be accurately determined. An approximation can be made by calculating the difference in useable storage between the start and the end of the period, and adding the net amount added to storage by collection during the same period and adding electrical useage.

Useable heat at 1 October 1981	111 600 MJ
Useable heat at 20 January 1982	23 300 MJ
Difference	88 300 MJ
Net heat added October 1981 - 20 January 1982	60 000 MJ
Amount used	148 300 MJ
Electric boiler	137 400 MJ
Estimated DHW by electricity	50 000 MJ
Total Building Load	335 700 MJ

Meteorological records show that the period covered was close to normal as regards heating load.

The predicted performance by the designers of the system, Hooper and Angus, in the Aylmer Design Manual produced in April 1979, is compared below with the actual performance.

	Predicted	Actual
Solar Radiation Collected	3.84×10^5 MJ	3.48×10^5 MJ
Total Heat Usage Solar and Electrical Space and DHW	2.95×10^5 MJ	3.36×10^5 MJ

It would appear from the above, that the solar system should be capable of supplying all of the space heating and most of the domestic hot water heating. A full season of operation with continuous monitoring will be necessary to fully establish the characteristics of the system.

Performance since the end of April 1982 is as follows:

	Collected	Added to Storage
May 1982	37 440 MJ	33 860 MJ
June 1982	28 080 MJ	20 350 MJ
July 1982	33 940 MJ	29 710 MJ

The figure for June includes some heat used for DHW.

Collected figures are taken from energy meter readings. Storage figures are calculated from storage temperatures. For most of this period, two of the collectors were not functioning.

8.2 Operating Problems and Solutions

During the operation period since April 1981 when the modification program was completed, a number of operating difficulties have arisen. These problems and the corrective measures initiated are as follows:

.1 The automatic control of the collector pump system had been performing in an erratic manner which became worse in the Spring of 1982. Investigation showed that Pumps P3 and P4 would alternate at frequent intervals during normal automatic operation. Eventually, the operator was running both pumps simultaneously on manual control as the only method to avoid damage to the alternator and magnetic starters from repeated frequent alternations. It was suspected that the problem was in the automatic control system which starts and stops the pumps in response to sensors in one of the collectors, and in the storage tank which respond to a differential temperature. A service representative from Honeywell Controls checked and calibrated the system, but the problem persisted. After a series of tests, it was found that the problem originated in Flow Switch FS1 in the return pipe from the collector system. By bridging the electrical connections on this switch, the system was made to

perform properly. The flow switch was removed, it was found to be improperly installed, had suffered damage, and the electrical circuitry was improperly designed. As the location of the switch was relatively inaccessible and the piping configuration did not permit proper installation, it was decided to remove the switch, plug the opening, and permanently bridge the wiring. The system has operated satisfactorily since. It would have required major changes to the mechanical and electrical systems to allow this switch to perform its intended function of protecting the pumps in the event of lack of water at the suction.

.2 An inspection of the heat recovery wheel in the ventilating system showed that this was carrying a heavy dust load. The only filters in the system are located in the air stream downstream of the wheel. This means that the wheel has no protection from particulate matter in the fresh air supply, or in the return air from the suites. There should be filters in the supply and return air to protect the wheel against eventual loss of function.

.3 Loss of storage tank water in the middle of January 1982 was investigated and it was found that four collector panels in the lower row were leaking badly. The collector pump was shut down from the 20th January until 2nd April after isolating valves had been installed on the leaking panels. In July 1982, the four leaking panels were removed and replaced with three which were in stock at the site, and one new one supplied by the manufacturer. An inspection of the damaged panels showed that the copper piping in the panels had split. In three panels, the split was in the bottom connecting piping below the bottom header and in one the split was in one of the vertical collector tubes just above the bottom

header. The damage had obviously been caused by water freezing in the tubes.

It was noted that the horizontal part of the connecting pipe from the lower header in the panels inspected, had a negative slope so that water could be trapped in this section. The pipe was originally horizontal but as it was free at one end, it could be pushed up during installation, resulting in a negative slope for draining. Appendix "D" is a sketch showing a typical collector arrangement. It was probable that some water could be trapped which would freeze under extreme climatic conditions. The fact that the lower collectors only were affected, could be explained by the probability that there would be a siphon effect resulting from the drainage of the lower collectors. It is believed that the damage occurred on the 17 January. The meteorological station at London reported the following for 16-17-18 January 1982:

	Temperatures °C		Wind Velocity Km/h			Hours
Date	Min.	Mean	Avg.	Max.	Wind Direction	Bright Sunlight
16 Jan.	-25.3	-15.8	32.8	46.0	W	2.7
17 Jan.	-26.1	-22.3	26.8	35.0	WSW	4.2
18 Jan.	-18.9	-15.6	11.4	19.0	S	0.2

Wind conditions at Aylmer would probably be more severe due to proximity to Lake Erie.

It is noted that the amount of sunshine on both the 16th and 17th January would have caused the solar pumps to operate, probably several separate times on the 17th. This, coupled with the high wind and low temperature, would provide the conditions leading to freezing of the

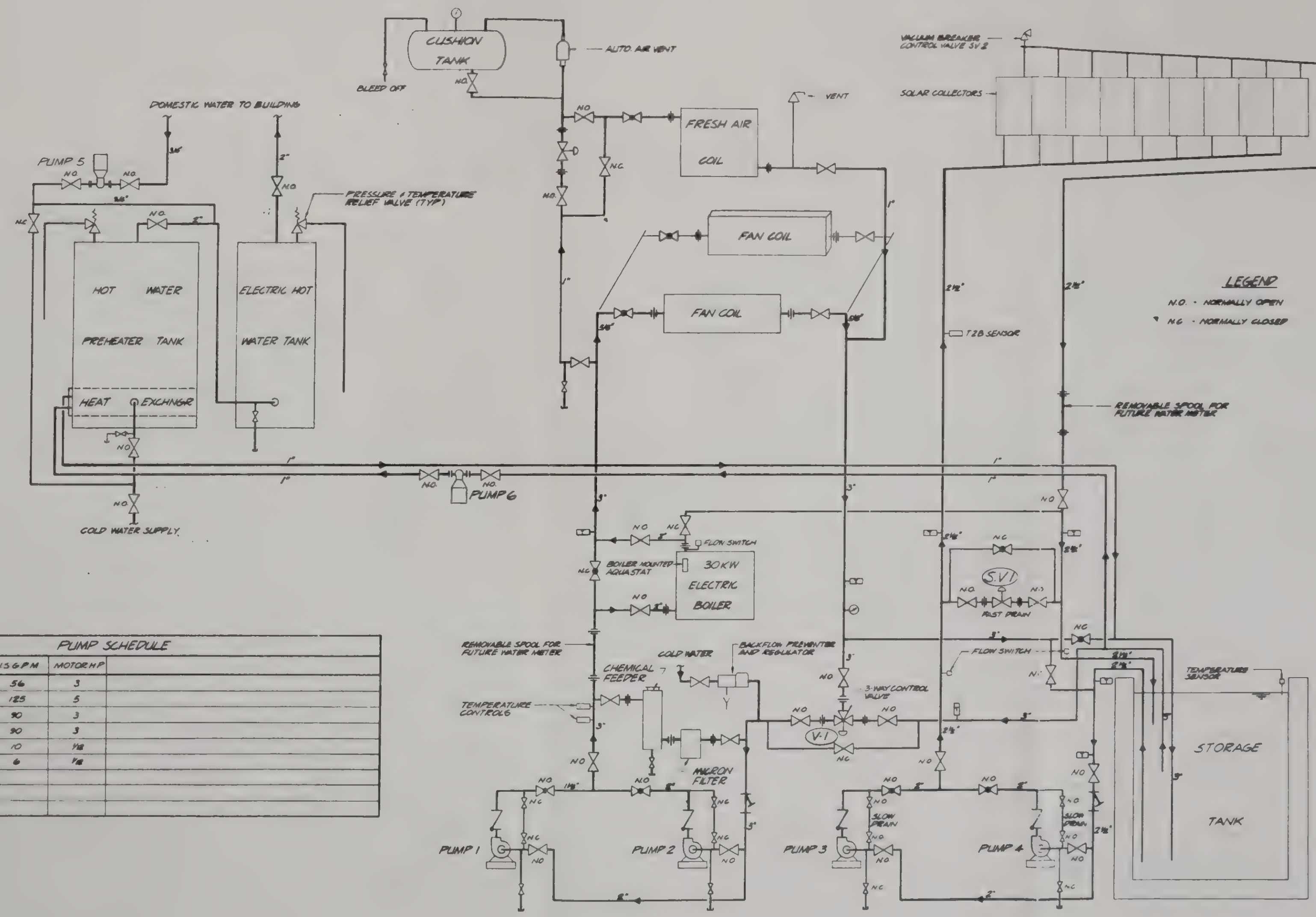
collector pipes. As there may be other collectors with a similar defect in the lower connection pipe, it would be wise to manually switch off the collector pumps under similar severe weather conditions. The amount of collected heat involved would be negligible.

.4 It had been realized for some time that operation of the domestic hot water preheat system was erratic. Records show that it had operated at times. When Pump P10 operates, the preheat system performs well as there is a positive suction pressure on Pump P6.

When P10 is not operating, P6 will provide circulation for a while, then this will stop. The reason is that the type of circulation pump installed needs a positive suction head to operate. As the suction from the tank has a siphon conformation requiring the pump to develop a negative suction head, operation of this pump is likely to be erratic.

Replacement of the present pump with a different type would probably solve this problem.

G. E. Humphries, P. Eng.



PUMP SCHEDULE

PUMP Nº	SERVICE	USGPM	MOTOR HP	
P-1	HEATING PUMP	56	3	
P-2	HEATING PUMP	125	5	
P-3	COLLECTOR PUMP	90	3	
P-4	COLLECTOR PUMP	90	3	
P-5	DHW RECIRC PUMP	10	1/12	
P-6	HEAT EXCH PUMP	6	1/12	

M. M. DILLON LIMITED

DATE

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REVISIONS

H.J.G.

JAN '81

NTS

AYLMER SOLAR HEATING SYSTEM

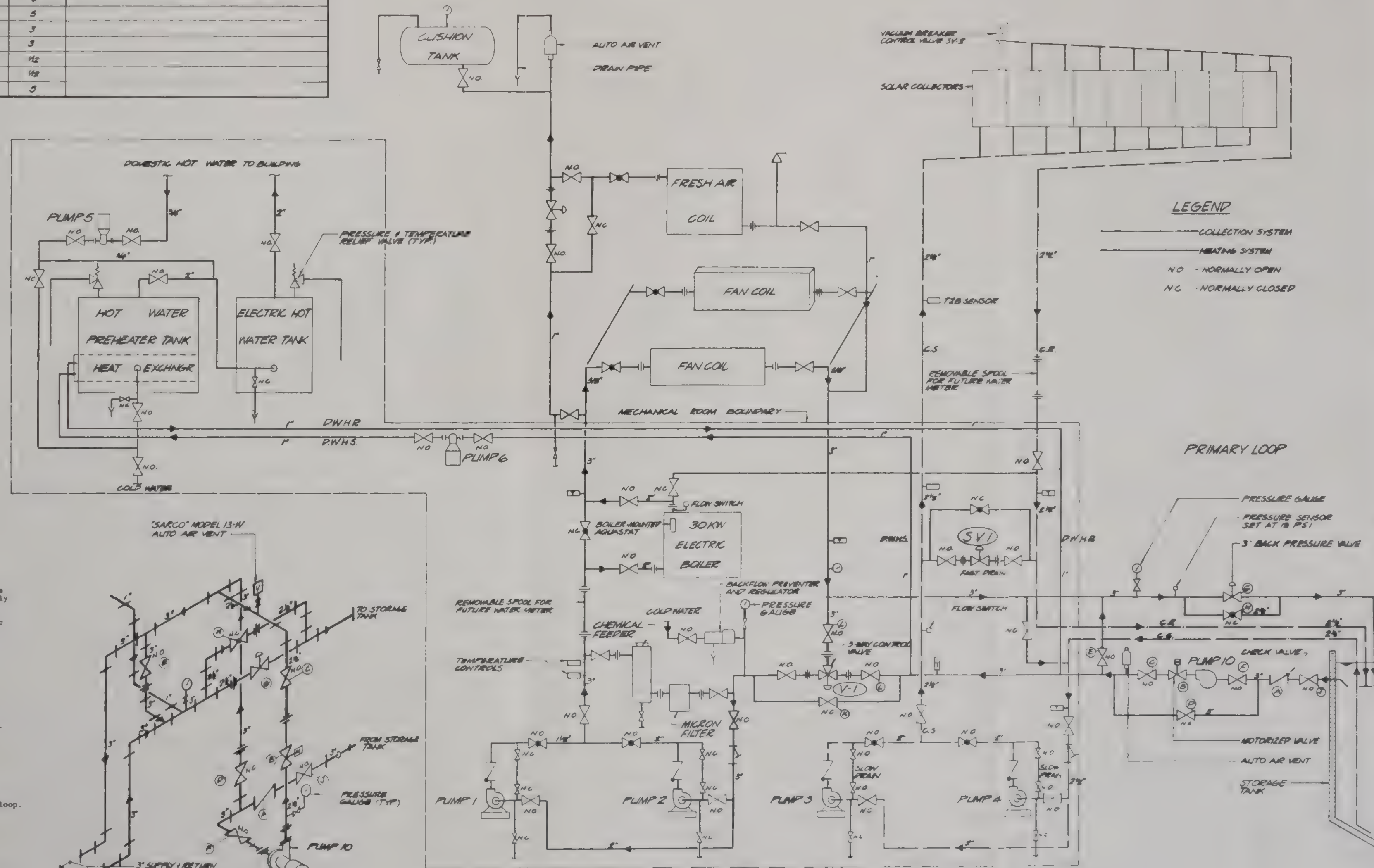
8765-05

MECHANICAL FLOW DIAGRAM
APPENDIX 'A' - ORIGINAL

1

2

PUMP SCHEDULE				
PUMP Nº	SERVICE	U.S. G.P.M.	MOTOR H.P.	
P 1	HEATING PUMP	36	3	
P 2	HEATING PUMP	125	5	
P 3	COLLECTOR PUMP	90	3	
P 4	COLLECTOR PUMP	90	3	
P 5	D.H.W. RECIRC PUMP	10	1/12	
P 6	HEAT EXCH PUMP	6	1/12	
P-10	RECIRCULATING PUMP	200	5	



PRIMARY LOOP OPERATION

Normal Operation on Tank Water

1. Pump 10 operates
2. Valves J F C E are open
3. Valves H and D closed
4. Motorized valve B is fully open
5. Back pressure valve G controls pressure to setting of pressure sensor - normally 18-20 psi
6. 3-way valve will mix tank and return water to temperatures set on aquastatic on discharge of pumps 1 and 2.

Operation on Electric Boiler

1. Manual switch or timer will go to ON position
2. Pump 10 will stop
3. Motorized valve B will close
4. 3-way valve will go to full recirculative position
5. Pump P2 will run
6. Aquastatic on electric boiler will control temperature of water to system.

Emergency Operation In Case of Failure Of Pump 10 or Pressure Controls

1. Shutdown pump 10
2. Manually close valves E and C
3. Manually open Valves H and D.

System will then operate directly in tank exactly as before installation of primary loop.

Emergency Operation. In Case of Failure Of Pumps 1 and 2

1. Run pump P10
2. Close valve E and L
3. Open valve K.

Water will now flow at full tank temperature to heating system.

ISOMETRIC VIEW OF PIPING MODIFICATIONS IN EXISTING ACCESS PIT

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AYLMER SOLAR HEATING SYSTEM

MECHANICAL FLOW DIAGRAM
APPENDIX 'B' MODIFIED

8765-05

2

OF 2

RECEIVED APR 1 6 1982

CONTROL OF COLLECTOR AND STORAGE WATER

When the outdoor air temperature is above the setting of low limit controller (LL), fast drain solenoid valve (SV1) and vacuum breaker (SV2) will be in the closed position.

When differential temperature control (MP11) (Module T02B) senses that the collector temperature is 15°F. higher than the temperature of the water in the storage tank, (Module R02D) relay contacts 27 and 29 will 'make', which will energize time delay relay (TM1). At this time, (TM1) contacts will immediately transfer and the time delay will be initiated. (Contacts 1 to 3 'make', holding power on the timer motor even if differential temperature controller (MP11) (Module R02D) 'breaks' circuit.) (Contact 8 to 6 'make', energizing relays (R14) and (R15), starting both pumps (P-3) and (P-4).) At the end of the 5 minute timing period, the output contacts return to their normal position. (Contacts 1 to 3 'break', taking power off the timer motor), (Contacts 8 to 6 'break', de-energizing relays (R14) and (R15), eliminating the paralleling of the pump starter coils, which now will be operated in an alternating manner by the electrical alternator, providing flow switch (FS1) has established that flow exists in the return line to the storage tank, and that differential controller (MP11) (Module T02C) establishes the fact that there is at least a 2°F. difference in temperature between the collector and the storage tank. The pump will continue to run until differential controller (MP11) (Module T02C) senses less than a 2°F. difference in temperature between the collector and the water storage tank. At this time, the circulating pump will stop.

Det./Dét.	Mat'l/Mat.	Description	Req.

AYLMER SOLAR HEATED HOME
AYLMER, ONTARIO

Mat'l spec. Spéc. mat.	
Finish Fini	
Ref. No. N^{o} de réf.	
Job No. N^{o} de projet	131428
Drawn Dessinateur	ks
Checked Vérificateur	
Approved Approbation	
Date	JUNE 1/78
Scale Échelle	

Honeywell

Title Titre: SEQUENCE OF OPERATION

For Pour: AYLMER SOLAR HEATED HOME

Dwg. No. N^{o} du dessin: 131428-A-S

Page 1 of 4

Rev. Rév.

Limits unless noted / Limites sauf indication contraire
± ______ x
± ______ x.x
± ______ x.xx
± ______ Other/Autre
± ______ Angles

No. N^{o}	Revision Révision	Date	E.C.N. Mod. techn.	App'd Appr.
2	Revision Update	4/82		
1	To match drawing Revision 'D'	6/16 '78		

CA-1584B-R9/80

The pump will remain stopped until differential temperature controller (MP11) (Module T02B) again senses a 15°F. difference in temperature between the collector and the water storage tank and at this time the cycle will be repeated and at this time the alternator will operate the pump which had been the standby pump on the previous cycle.

Should the outside air temperature fall below the setting of low limit controller (LL), and no flow is sensed by flow switch (FS2), relay (R13) will be de-energized, opening the fast drain solenoid valve (SV1) and the vacuum breaker valve (SV2). However, if flow switch (FS2) senses 'flow' relay (R13) will be energized and the fast drain solenoid valve (SV1) and vacuum breaker valve (SV2) will remain in the closed position to allow for winter operation. (Valves normally open.)

CONTROL OF HEATING WATER SUPPLY

When the water temperature in the storage tank is above 110°F., relay (R11) will be de-energized, allowing low capacity pump (P1) to operate. With pump (P1) operating, relay (R12) will be energized allowing temperature controller (T14) to modulate 3-way valve (V12) in accordance with its temperature setting of 110°F., Relay (R18) will be de-energized allowing new pump (P10) to operate, new valve (V2) to open and new valve (V1) will balance the operating pressure at 20 p.s.i.

When the water temperature in the storage tank falls below the setting of temperature controller (T13) (110°F.), relay (R11) will be energized, stopping pump (P1) and starting pump (P2). At this time, relay (R12)

will be de-energized, allowing temperature controller (T15) to modulate 3-way valve (V12) in accordance with its temperature setting of 85^{O}F. Pump (P10) is still operational and 20 p.s.i. is held in the system by the modulation of valve (V1) controlled by pressuretrol (L91B).

SUPPLEMENTARY ELECTRIC WATER HEATING

Supplementary electric water heating is provided by an electric heater controlled as follows:

Timer (TM2) will make circuit during a 12 hour period per day, during an off peak load power consumption time of day. Manual toggle switch (S1) is manually switches to the "on" position by the operator if the storage tank water temperature is below the temperature listed on a schedule provided by computer analysis showing what temperature the storage tank water should be, for any particular day of the year.

When (S1) is switched to the "on" position, temperature controller (T16) will operate the electric heater to maintain its setting of 85^{O}F. At the same time, relay (R17) will be energized, one set of relay (R17) contacts will parallel temperature controller (T13) R & W connections, which will energize relay (R11), starting high capacity pump (P2). The other set of relay (R17) contacts will drive three way valve (V12) to the "A" to "AB" position, which will allow the return water from the fan coil units to bypass the storage tank, and be heated by the electric water heater only. (No attempt is made to heat the storage tank water with the electric water heater.) Relay (R18) is also energized which breaks power

Det./Dét.	Mat'l/Mat.	Description	Req.

AYLMER SOLAR HEATED HOME
AYLMER, ONTARIO

Mat'l spec. / Spéc. mat.
Finish / Fini
Ref. No. / N° de réf.
Job No. / N° de projet: 131428
Drawn / Dessinateur | Checked / Vérificateur | Approved / Approbation
Date: June 1/78
Scale / Échelle
Limits unless noted / Limites sauf indication contraire
± ______ X
± ______ X.X
± ______ X.XX
± ______ Other/Autre
± ______ Angles

Honeywell

Title / Titre: SEQUENCE OF OPERATION

For / Pour: AYLMER SOLAR HOME

Dwg. No. / N° du dessin: 131428-A-S | Rev. / Rév.

No. / N°	Revision / Révision	Date	E.C.N. / Mod. techn.	App'd / Appr.

CA-1584B-R9/80

(P10) and valves (V2) and (V1) which will both spring return closed.

CONTROL OF DOMESTIC HOT WATER

Temperature controller (T12) with its sensing bulb located in the domestic hot water storage tank will operate circulating pump (P6) in accordance with its temperature setting of 120°F.

CONTROL OF HEAT WHEEL

Temperature controller (T11) with its sensing bulb located in the discharge air will modulate heating valve (V11) in accordance with its temperature setting of 70°F. (N.O. valve).

Firestat (F11) will stop the heat wheel should this device sense a temperature in excess of its setting. This device must be manually reset before the unit can be restarted, (set point 135°F.) and located upstream of the exhaust fan.

Freezestat (FR11) will stop the heat wheel should the temperature sensed fall below its setting. This device must be manually reset before the unit can be restarted.

AYLMER SOLAR HEATED HOME
AYLMER, ONTARIO

Det./Dét.	Mat'l/Mat.	Description	Req.

Mat'l spec. Spéc. mat.

Finish Fini

Ref. No. N° de réf.

Job No. N° de projet 131428

Drawn Dessinateur | Checked Vérificateur | Approved Approbation

Date June 1/78

Scale Echelle

Honeywell

Title Titre SEQUENCE OF OPERATION

For Pour AYLMER SOLAR HOME

Dwg. No. N° du dessin 131428-A-S

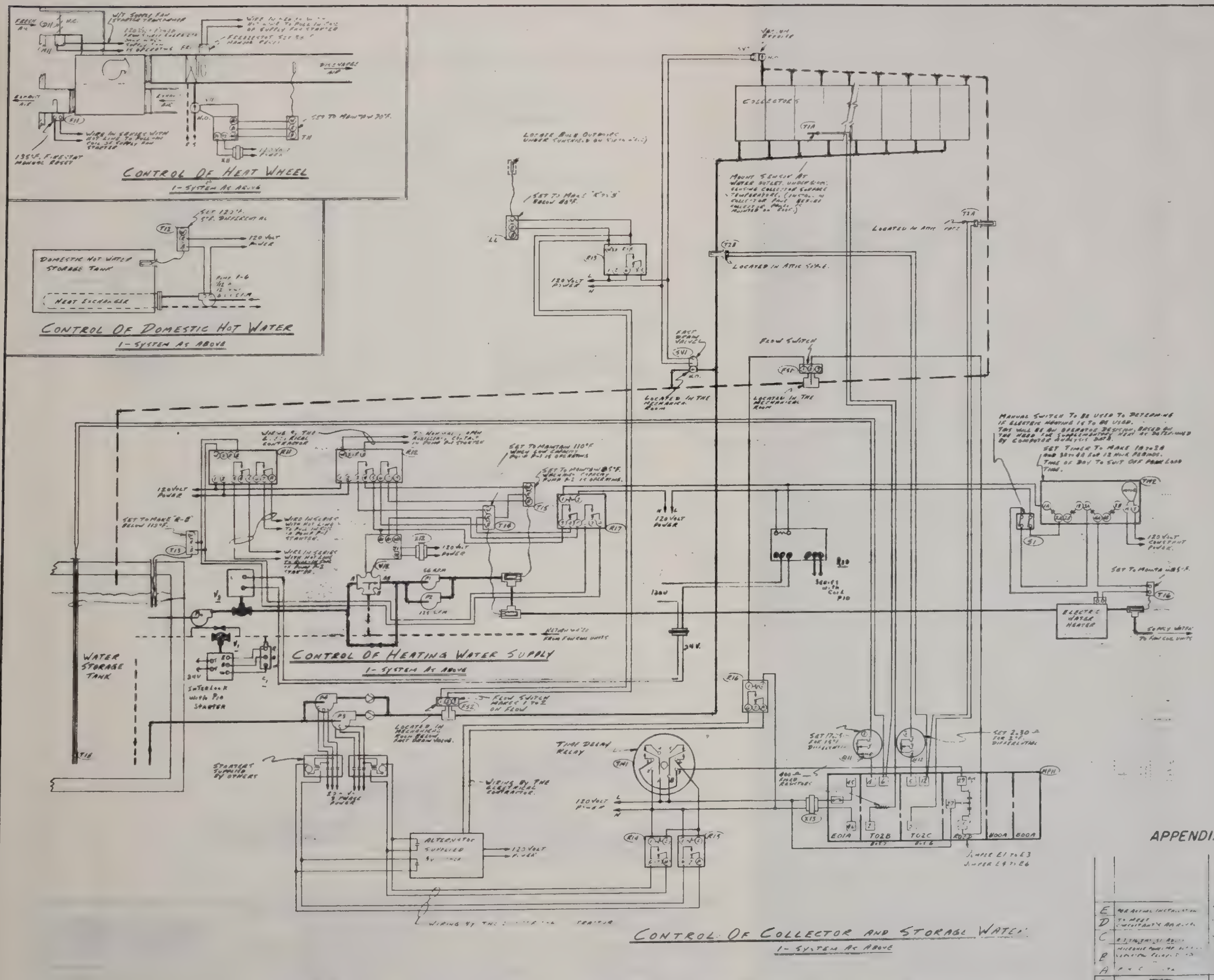
Page 4 of 4

Rev. Rév.

Limits unless noted
Limites sauf indication contraire
± ______ X
± ______ X.X
± ______ X.XX
± ______ Other/Autre
± ______ Angles

No. N°	Revision Revision	Date	E.C.N. Mod. techn.	App'd Appr.

CA-1584B-R9/80



EQUIPMENT SUMMARY

CONTROL OF HEAT WHEEL

T11	1 -	T991A1004	Temp. Control, range 0 to 100°F.
	1 -	3112660	Bulb Holder.
FR11	1 -	L480G1044	Freezestat, range 20 to 60°F.
F11	1 -	L4029E1011	Firestat, 135°F.
		X945	Valve Assembly
		CONSISTING OF:	
	1 -	M945F1004	Motor, 24 Volt. (Normally open).
	1 -	Q618A1024	Linkage.
V11	1 -	V5011A1221	1" Screwed Valve, C.V.; 10.0.
X11	1 -	AT72D1188	Transformer, 120:24 Volts, 40 V.A.
D11	1 -	D640	Damper c/w neoprene edges
M11	1 -	M445A1018	Motor, 120 Volt.
	1 -	Q605A1070	Linkage
	1 -	A27520E	78" Pushrod.

CONTROL OF DOMESTIC HOT WATER

T12	1 -	T675A1052	Temp. Control, range 80 to 180°F. 5' capillary.
	1 -	112622AA	Well 1/2" x 4" x 1/2" N.P.T.

CONTROL OF HEATING WATER SUPPLY

T13	1 -	T675A1060	Temp. Control, range 80 to 180°F. (20' capillary).
	1		Well (special).
T14, T15	2 -	T991A1046	Temp. Controls, range 80-180°F. (20' capillary).
	2 -	112622AA	Wells, 1/2" x 4" x 1/2" N.P.T.
R11, R12	2 -	R182C1002	Relays, 120 Volt, D.P.D.T.
X12	1 -	AT72D1188	Transformer, 120:24 Volts, 40 V.A.
		X936	Valve Assembly
		CONSISTING OF:	
	1 -	M944A1010	Motor, 24 Volt.
	1 -	Q618A1024	Linkage.
V12	1 -	V5013B1011	3" Flanged Valve, C.V., 100.0.
R17	1 -	R482C1006	Relay, 120 Volt, D.P.D.T.
T16	1 -	L4008C1044	Temp. Controller, range 40 to 180°F.
TM2	1 -	7008-00	Paragon Timer, 7-Day, 120 Volt Motor.
S1	1 -	113703	Toggle Switch, D.P.D.T.

CONTROL OF COLLECTOR AND STORAGE WATER

T1A	1 -	YM001-5 1/2-3A	Sensor, 100 OHMS, 10 ft. lead.
T1B	1 -	YM001-5 1/2-3A	Sensor, 100 OHMS, 40 ft. lead.
	1 -		Well, (special). (Make up locally)
FS1, FS2	2 -	FS4-3	McDonnell & Miller Flow Switches.
R13	1 -	R182B1003	Relay, 120 Volt, S.P.D.T.
R14, R15, R16	3 -	R482B1007	Relays, 120 Volt, S.P.D.T.
LL	1 -	T675A1003	Temp. Control, range 0 to 100°F.
	1 -	34886A	4" Sun Shield.
TM1	1 -	9032B11L	Agastat Time Delay Relay, 30 to 600 secs. 120 V.
	1 -	27E122	Octal Base, Potter Brumfield (or equal).
SV1, SV2	2 -	8210035	Asco Solenoid Valves, 3/4", C.V. 5.5, 120 V. Coil
T2A, T2B	2 -	L7033A1165	Sensors, 500 OHM, 4 1/2" insertion c/w well.
MP11	1 -	W7500BXXXXX01A 1C/2B E01A/T02B/T02C R02D/B00A/B00A	Micronik Panel, 24 Volts.
	1 -	43512002-301	Six Position Field Terminal Box
X13	1 -	AT72D1188	Transformer, 120:24 Volt, 40 V.A.
Q11	1 -		20 Ohm Potentiometer.
Q12	1 -		20 Ohm Potentiometer.
	2 -		400 Ohm Precision Resistors.
V_1, V_2	2		[illegible]
C_1	1		[illegible]
R_{10}	1		[illegible]

PANEL

	1 -	40889086-001	Door Assembly.
	1 -	40889087-001	Cabinet Ring.
	1 -	40889089-001	Perforated Sub-Panel.

CUSTOMER: GILBERT PLUMBING AND HEATING LTD.,
P.O. BOX 68,
HANNON, ONTARIO.

JOB ADDRESS: AYLMER SOLAR HEATED HOME,
MYRTLE STREET,
AYLMER, ONTARIO.

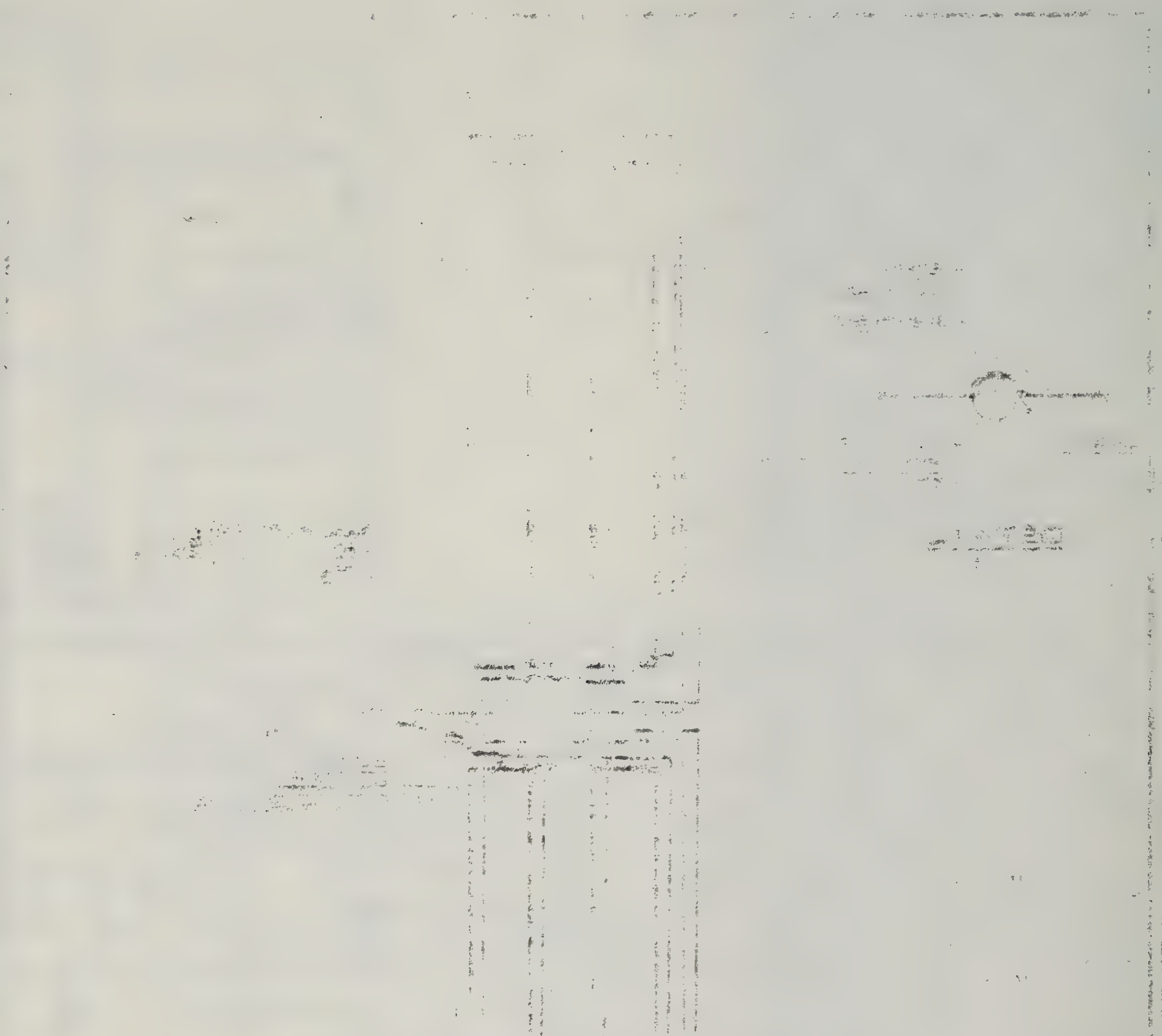
APPENDIX 'C'

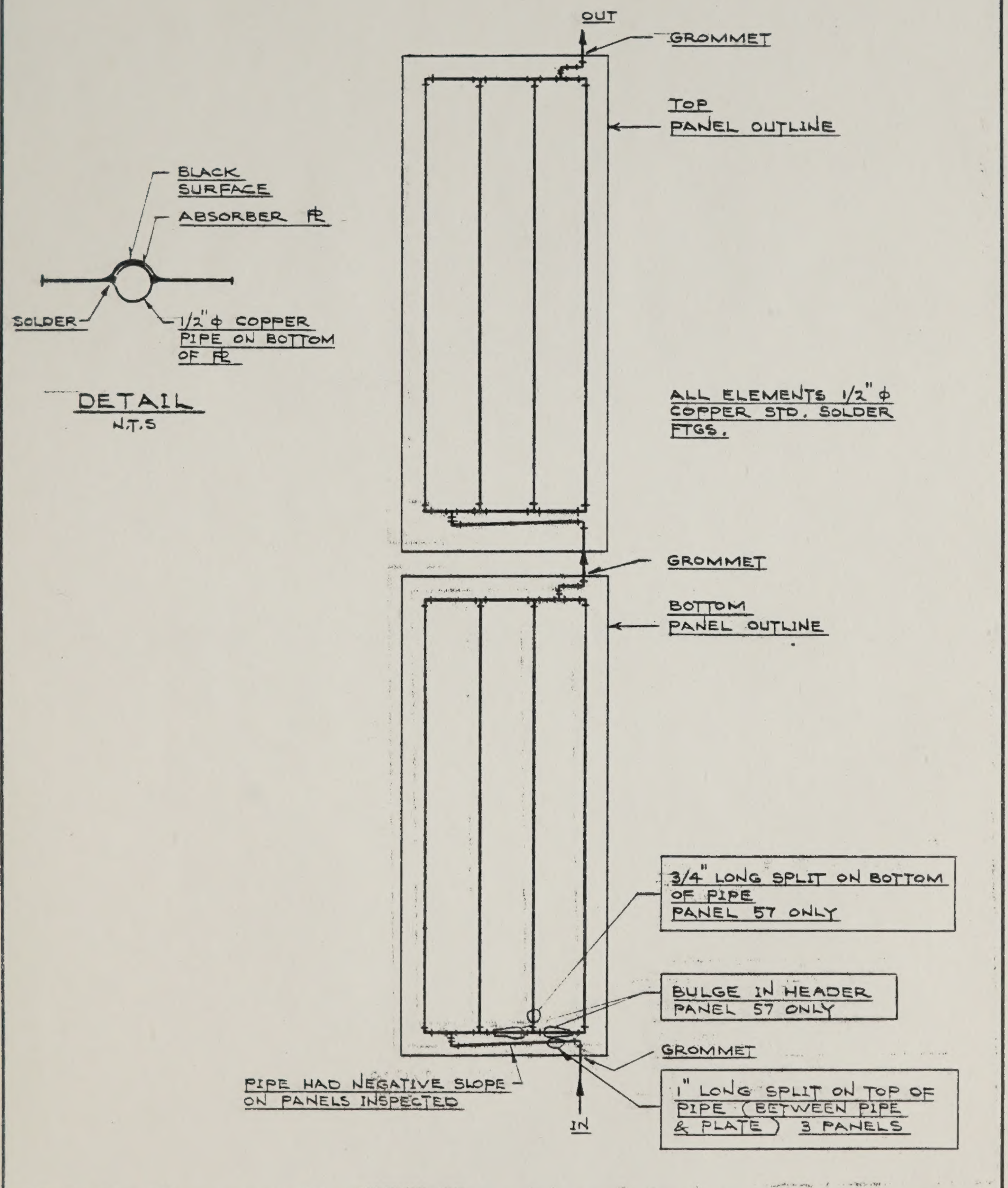
No	REVISION	DATE	ECN	APP'D
E	PER ACTUAL INSTALLATION	OCT 12 1978		
D	TO MEET CONSULTANT'S APPROVAL	[illegible] 1978		
C	[illegible]	[illegible] 1978		
B	MICRONIK PANEL MP [illegible] RELAYS [illegible]	[illegible] 1978		
A	[illegible]	[illegible]		

DET	MAT'L
MAT'L SPEC	R H W S W L
FIGURE	A-1-D-12-10-78
REF. No.	
JOB No.	131428
DRAWN	ARM
CHECKED	
APPROVED	
DATE	DEC 5, 1977
SCALE	not to scale
TITLE	CONTROL SYSTEMS
FOR	AYLMER SOLAR HOME
DWG. No.	131428-D-C SHEET 1 of 1
REV	E

HONEYWELL CONTROLS LIMITED
HEAD OFFICE

CA 1887





DILLON Consulting Engineers & Planners	TITLE TYPICAL COLLECTOR PANEL ARRANGEMENT	PROJECT NO. 8765-03-X01
DATE AUG. 20, 1982	PROJECT AYLMER SOLAR HEATING SYSTEM	DETAIL NO. APPENDIX 'D'

MMD-501-72 (REV. 2)

Ontario
Renews

Ministry of Municipal Affairs
and Housing
Communications Branch
Ontario

2M/1-82/PW 115